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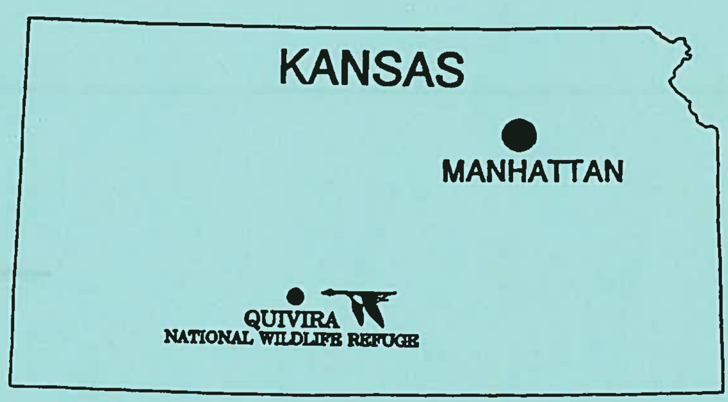
CONTAMINANTS IN INTERIOR LEAST TERN AND SNOWY PLOVER EGGS FROM QUIVIRA NATIONAL WILDLIFE REFUGE IN 1992



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U.S. FISH AND WILDLIFE SERVICE
Fish and Wildlife Enhancement
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CONTAMINANTS IN INTERIOR LEAST TERN AND SNOWY PLOVER EGGS FROM QUIVIRA NATIONAL WILDLIFE REFUGE IN 1992

by

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SUMMARY

▸ Four flooded or abandoned eggs of interior least terns (*Sterna antillarum*) and four flooded or abandoned eggs of snowy plovers (*Charadrium alexandrinus*) that nested at Quivira National Wildlife Refuge in central Kansas were collected in 1992. The eggs were analyzed for arsenic, mercury, selenium, and chlorinated hydrocarbons.

▸ Arsenic was not detected in any egg, and concentrations of selenium were below the levels at which markedly harmful effects on hatchability or survival are likely to occur.

▸ The mercury concentration in two of the least tern eggs was above what is considered safe. We suspect that the high concentrations were due to exposure to mercury prior to arrival at the refuge.

▸ The cyclodiene (primarily chlordane compound) concentration in one least tern egg exceeded, and in two snowy plover eggs equalled, the 0.10 µg/g concentration considered detrimental in biota.

▸ The p,p'-DDE concentrations in both tern and plover eggs were unlikely to cause observable harmful effects. The occurrence of DDT in four of the eggs indicates that the females likely were exposed to DDT just prior to migration.

▸ Unlike the earlier analyses of least tern eggs from Quivira, the analyses of least tern and snowy plover eggs from 1992 indicate that mercury and chlordane compound concentrations in tern and plover eggs at the refuge should be monitored, and that examination of food sources for the two species in their wintering areas and on the refuge is warranted.

ABBREVIATIONS AND CONVERSION FACTORS

Abbreviations

micrograms per gram = $\mu g/g$

Conversions

1 microgram per gram = 1 part per million (ppm)

ACKNOWLEDGMENTS

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INTRODUCTION

The interior population of the least tern (*Sterna antillarum*) was listed as endangered in 1985 (50 Federal Register 21,784-21,792). The U.S. Fish and Wildlife Service (Service) and other agencies are involved in efforts to increase the population of the interior least tern, as outlined by Sidle and Harrison (1990). The primary reason for listing the interior least tern as endangered was population reductions due to changes in the historic flow regimes along central U.S. rivers that caused losses of habitat. Wintering areas of interior least terns include coastlines of Central America and South America (Sidle and Harrison 1990), where use of persistent chlorinated hydrocarbon pesticides continues. The potential for interior least terns and snowy plovers to accumulate contaminants from wintering locations justifies evaluation of contaminant levels in eggs when they become available.

Quivira National Wildlife Refuge (Quivira) is one of two remaining nesting locations for least terns in Kansas. The Service has undertaken several measures to enhance least tern nesting on the refuge (D. Hilley, U.S.F.W.S., personal communication).

Biologists at the refuge collected flooded or abandoned least tern and snowy plover (*Charadrium alexandrinus*) eggs for contaminants analyses in 1992. The snowy plover egg collections were not planned, but when the eggs were available, we believed that chemical analyses of their contents could provide useful information. This report on contaminants in the eggs collected in 1992 is part of continuing evaluation of contaminants in shorebird eggs from Quivira (Allen 1992).

STUDY AREA AND METHODS

Quivira National Wildlife Refuge is located in Stafford, Reno, and Rice counties in south-central Kansas. The 8,600 hectare refuge was purchased from private landowners in 1959. The Service owns surface rights to refuge lands, but mineral rights are held by others. Numerous oil production facilities were in place when the refuge was purchased. Oil production has continued and some new production facilities have been developed. Two recent studies (Allen 1991, Allen and Wilson 1990) indicated that there are no major contaminants problems on the refuge. However, a Kansas Geological Survey study (Sophocleous 1992, Sophocleous and Perkins 1992) indicated that selenium concentrations in water in Rattlesnake Creek sometimes are high.

Interior least terns and snowy plovers nest on the Big Salt Marsh at the refuge (Figure 1). Nesting is monitored each year, and in July 1992 biologists collected four intact addled, abandoned, flooded least tern eggs and four intact snowy plover eggs. We do not know if any of the eggs of either species were from the same clutch.

Past sampling (Allen 1992) had indicated that concentrations of most metals in least tern eggs from Quivira were not of concern. Therefore, in 1992, egg contents were analyzed individually for arsenic, mercury, and selenium using atomic absorption spectroscopy by the Environmental Trace Substances Research Center in Rolla, Missouri. Dry weight detection limits for the metals analyzed were 0.2 μg/g for arsenic, 0.02 μg/g for mercury, and 0.2 to 0.3 μg/g for selenium.

Aliquots of the eggs were analyzed for organochlorine compounds by the Mississippi State Chemical Laboratory (MSCL) in Mississippi State. The concentrations were determined using electron capture gas chromatography. MSCL analyzed for alpha-benzene hexachloride (BHC), beta-BHC, delta-BHC, gamma-BHC (lindane), hexachlorobenzene, alpha-chlordane, gamma-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane, heptachlor epoxide, dieldrin, endrin, mirex, toxaphene, o,p'-DDT, p,p'-DDT, o,p'-DDE, p,p'-DDE, o,p'-DDD, p,p'-DDD, and total PCBs. Wet weight concentrations were reported for organochlorines. The detection limit was 0.01 μg/g wet weight for all organochlorines except PCBs and toxaphene, for which the detection limit was 0.05 μg/g. Lipid-normalization of organic compounds does not improve data reporting (Huckins *et al.* 1988, Schmitt *et al.* 1990), so we do not report lipid concentrations. We did not measure eggshell thicknesses.

No anomalies were reported in the samples. Laboratory quality assurance and quality control were responsibilities of the Service's Patuxent Analytical Control Facility. All analyses met the QA/QC standards established by the Service. Precision and accuracy of the laboratory analyses were confirmed with procedural blanks, duplicate analyses, test recoveries of spiked materials, and reference material analyses. Round-robin tests among the analytical laboratories also were part of the quality control. Analytical results were not adjusted to reflect spike recoveries. Tests of reference standards were not done for organic compounds.

The stage of incubation of the eggs collected was variable. Therefore, no conclusions relating contaminant levels to incubation stage should be drawn from the analytical results.

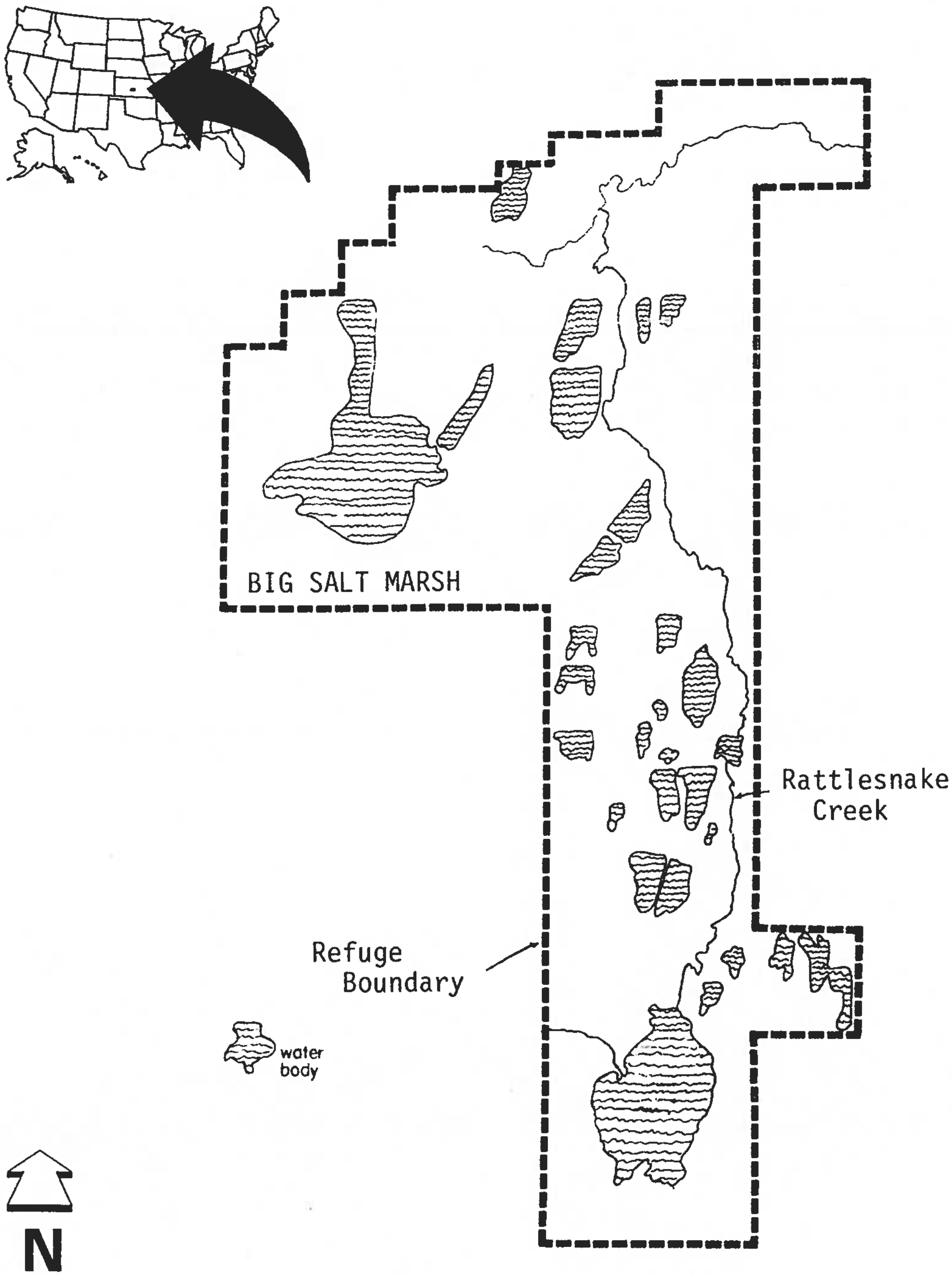

Figure 1. Big Salt Marsh egg sampling location at Quivira National Wildlife Refuge, Kansas, 1992.

RESULTS AND DISCUSSION

ARSENIC, MERCURY, AND SELENIUM

Arsenic was not detected in any tern or plover egg. Mercury and selenium concentrations in the eggs are presented in Table 1.

Table 1. Mercury, and selenium concentrations in µg/g in interior least tern and snowy plover eggs from Quivira National Wildlife Refuge, Kansas, 1992.

		Element Concentration			
		Mercury		Selenium	
Species	Percent Moisture	Dry Weight	Wet Weight	Dry Weight	Wet Weight
Least Tern	74.4	0.99	0.25	4.6	1.2
Least Tern	77.6	4.7	1.1	3.8	0.85
Least Tern	70.4	4.4	1.3	2.6	0.77
Least Tern	74.0	0.69	0.18	4.2	1.1
Snowy Plover	71.2	0.41	0.12	1.7	0.49
Snowy Plover	73.3	0.75	0.20	1.8	0.48
Snowy Plover	62.7	0.54	0.20	1.4	0.52
Snowy Plover	71.5	0.46	0.13	1.7	0.49

King *et al*. (1991) found that wet weight mercury concentrations up to 0.91 µg/g in eggs of Forster's terns (*Sterna forsteri*) and up to 0.74 µg/g in eggs of black skimmers (*Rhyncops niger*) did not affect reproductive success. Vermeer (1971) analyzed mercury content in aquatic bird eggs in Saskatchewan and Manitoba, and found that herring gull (*Larus argentatus*) eggs that contained 0.5 to 2.0 µg/g wet weight hatched successfully. Egg concentrations up to 16 µg/g wet weight did not appear to affect herring gull hatching or fledging success in Ontario (Vermeer *et al*. 1973). Henny and Herron (1989) found no relationship between white-faced ibis (*Plegadis chihi*) productivity at Carson Lake, Nevada, and geometric mean mercury concentrations in eggs of up to 1.06 µg/g dry weight. King *et al*. (1980) found comparable concentrations in white-faced ibis eggs in Texas.

In least tern eggs from sites on the Missouri River in North Dakota, Welsh and Mayer (1992) found mercury concentrations of 0.08 to 1.48 µg/g dry weight in 1990 and 1.03 to 1.48 µg/g dry weight in 1991. Those concentrations were lower than those in two of the least tern eggs from Quivira. The maximum mercury concentration in least tern eggs from the Missouri River in South Dakota from 1988 through 1990 was 1.80 µg/g dry weight (Ruelle 1991).

Eisler (1987) concluded that a safe maximum mercury concentration in bird eggs is 0.9 µg/g wet weight. Two least tern eggs collected in 1992 from Quivira exceeded that concentration, but the other two tern eggs and all of the snowy plover eggs contained appreciably lower concentrations. Therefore, we suspect that the high levels in the two least tern eggs were due to exposure to mercury prior to arrival at the refuge.

Selenium is an essential trace nutrient for terrestrial and aquatic organisms, and probably will be found in most analyses of biota. The selenium tolerance of eggs of different species is variable (Heinz *et al.* 1987). Lemly and Smith (1987) concluded that the level of concern for selenium in bird eggs should be 15 to 20 µg/g dry weight. Skorupa and Ohlendorf (1991) stated that approximately 10 µg/g is the lower value for the concentration in individual eggs that reduced embryo viability in black-necked stilts (*Himantopus mexicanus*). The maximum concentration of selenium found in the eggs collected at Quivira in 1992 was 4.6 µg/g. Therefore, selenium does not appear to be of concern in the least tern or snowy plover eggs from Quivira.

The differences in mercury and selenium concentrations between least tern and snowy plover eggs from Quivira may be due to the differences in their foods. Least terns feed almost exclusively on fish, whereas snowy plovers feed on insects and aquatic invertebrates. We hypothesize that the higher concentrations in the tern eggs may represent the difference between mercury and selenium accumulation from water or from food that accumulates the contaminants directly in snowy plovers and accumulation as a result of accumulation in lower trophic level food items in least terns. Alternatively, the differences might be due to exposure at the wintering or migration stopover locations for the two species.

CHLORINATED HYDROCARBONS

Chlorinated hydrocarbon compound concentrations in the eggs are presented in Table 2. Many chlorinated hydrocarbon compounds were not detected in any egg.

Table 2. Chlorinated hydrocarbon compound concentrations in $\mu g/g$ wet weight in interior least tern and snowy plover eggs from Quivira National Wildlife Refuge, Kansas, 1992. ND = Not detected.

Species	Percent Moisture	Percent Lipid	Concentration: alpha BHC	gamma BHC	beta BHC	alpha chlordane
Least Tern	85.1	8.2	ND	ND	ND	ND
Least Tern	86.1	7.4	ND	ND	ND	ND
Least Tern	81.8	18.2	ND	ND	ND	ND
Least Tern	82.8	6.9	ND	ND	ND	0.03
Snowy Plover	80.6	12.0	ND	0.01	ND	0.01
Snowy Plover	82.3	16.0	ND	ND	ND	ND
Snowy Plover	76.5	6.8	0.01	ND	0.01	ND
Snowy Plover	81.3	13.8	ND	ND	ND	ND

Species	Concentration: gamma chlordane	cis nonachlor	trans nonachlor	oxy-chlordane	heptachlor epoxide	dieldrin
Least Tern	ND	ND	ND	ND	ND	ND
Least Tern	ND	ND	ND	ND	ND	ND
Least Tern	ND	ND	ND	ND	ND	0.02
Least Tern	ND	0.03	0.07	0.02	0.05	0.02
Snowy Plover	0.01	ND	ND	0.02	0.02	0.03
Snowy Plover	ND	ND	0.01	0.01	0.02	0.02
Snowy Plover	ND	ND	ND	0.01	0.01	0.01
Snowy Plover	ND	ND	0.05	0.01	0.04	ND

Species	Concentration: Cyclodiene Total	p,p'-DDT	p,p'-DDE	o,p'-DDD
Least Tern	ND	ND	0.10	ND
Least Tern	ND	ND	0.13	ND
Least Tern	0.02	0.02	0.16	0.02
Least Tern	0.23	0.01	0.15	0.03
Snowy Plover	0.10	0.01	0.05	0.03
Snowy Plover	0.06	ND	0.06	0.02
Snowy Plover	0.05	ND	0.06	ND
Snowy Plover	0.10	0.01	0.09	ND

The detection of chlordane compounds in five of the eggs, including all of the snowy plover eggs, was surprising. A cyclodiene compound (in this case chlordane compounds and dieldrin) concentration of 0.10 $\mu g/g$ wet weight in biota was considered detrimental by the National Academy of Sciences and National Academy of Engineering (1973). That concentration was exceeded in one least tern egg and equalled in two snowy plover eggs. The chlordane compound concentrations in terns and plovers eggs at the refuge should be monitored, and concentrations in food sources for the two species on the refuge should be determined. Chlordane has been found to be widespread in waters in Kansas (Arruda *et al.* 1987), although high levels in Quivira waters would be surprising. Chlordane compounds are harmful to adult birds (Blus *et al.* 1983, Stickel *et al.* 1979, 1983), but we do not know of the effects of the levels observed on least terns or snowy plovers.

Although the p,p'-DDE concentrations in least tern eggs were higher than those found in least tern eggs from Quivira in 1990 and 1991 (Mann-Whitney test, $P<0.01$), they were lower than the levels found to reduce productivity in studies of species such as hooded merganser and common goldeneye (*Bucephala clangula*) (Zicus *et al.* 1981), black skimmers (Custer and Mitchell 1987), white-faced ibis (Custer and Mitchell 1989, Henny and Herron 1989, Henny and Bennett 1990), and black-crowned night-herons (Henny *et al.* 1984).

The concentrations found in least tern eggs from Quivira were lower than organochlorine concentrations found in two of three least tern egg composites from the Missouri River in South Dakota in 1988 (Ruelle 1991). The occurrence of DDT in four of the eggs indicates that the females likely were exposed to DDT just prior to migration.

RECOMMENDATIONS

Arsenic, selenium and chlorinated hydrocarbon compounds were detected at levels that are unlikely to cause impaired egg hatchability or chick survival. Mercury concentrations in two least tern eggs, were at harmful levels. We recommend continued determination of mercury and selenium concentrations in foods of least terns and snowy plovers on the refuge to determine if concentrations detected in eggs were due to mercury or selenium on the refuge. In addition, monitoring of chlorinated hydrocarbon compound concentrations in wintering areas of the two species would elucidate possible causes of the differences in chlorinated hydrocarbon compounds in the eggs.

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